



Improving Tool Durability and Process Robustness in Assembly of Aluminum and Steel Sub-Components using Friction-Assisted Scribe Technology (FAST)

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Project ID # mat156

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Project Overview

Project Timeline

- ▶ Start: Q3FY2019
- ▶ Finish: Q3 FY2020
- ▶ 0% Complete

Budget

- ▶ Total project funding: \$300k
 - PNNL: \$10k
 - DOE: \$150k
 - Industry cost share: \$140k

Barriers

Techniques for joining aluminum to other metals are inadequate (slow and expensive).[Light duty workshop final report 3.3.1 and 3.3.1, 4.1 and US DRIVE MTT Roadmap 5.3]

Partners

- ▶ **Lead**
PNNL
- ▶ **Industry partner**
TWB company

► Overall Objective:

Overcome barriers in implementing friction stir assisted scribe technology in a high volume production environment. (addressing technology gap identified by USDRIVE Roadmap (Sec. 5.1) 2017).

► Impact

- Joining technology developed and transferred in this project will enable automotive lightweighting.
- By increasing the welding speed up to industrial viability, we are maturing a laboratory developed technology for commercialization.

Task flow and schedule

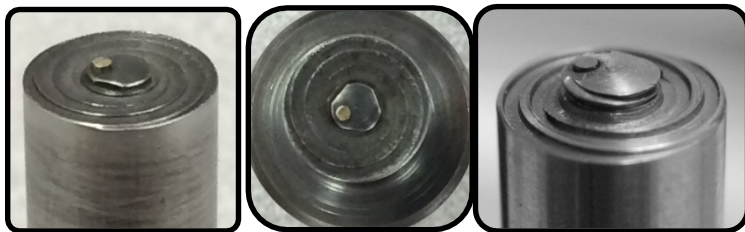
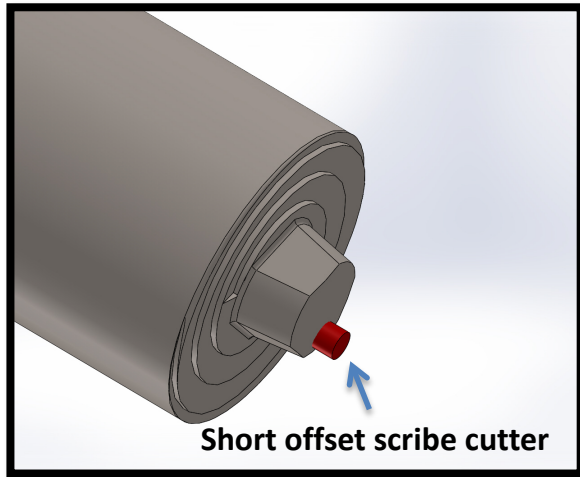
| Task | FY19Q3 | FY19Q4 | FY20Q1 | FY20Q2 |
|---|--------|--------|--------|--------|
| 1. Material configurations and baseline weld development | | | | |
| 1.1. Establish material combination and configurations | | | | |
| 1.2 Baseline Weld development and characterization | | | | |
| 1.3. Establish Joint performance criteria | | | | |
| Milestone 1 | | | | |
| 2. Production readiness and assessments | | | | |
| 2.1 FAST process and tool optimization | | | | |
| 2.2 Joint assessment | | | | |
| 2.3 Tool durability improvement and process assessments | | | | |
| Milestone 2 | | | | |
| Deliverable 1 | | | | |
| 3. Process technology transfer | | | | |
| Deliverable 2 | | | | |

Project Milestones and deliverables

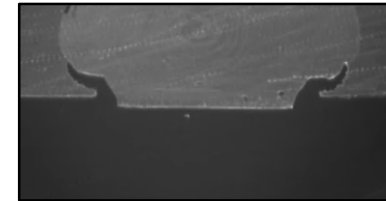
- ▶ **Milestone 1 (Q1):** Material combinations and configurations (eg. Sheet thickness, temper and surface treatment) defined, subcomponent and mechanical property requirements are established.
- ▶ **Milestone2 (Q3):** Performance criteria established in Milestone 1 will be reached such that the welding speed of 3m/min is demonstrated for Al/steel dissimilar joining.
- ▶ **Deliverable 1 :** A set of welding parameters, tooling details and its effect on weld properties and fracture modes.
- ▶ **Deliverable 2:** Final report describing baseline performance of FAST joints including comparative analysis of joint performance vis-à-vis commercialization targets.

Any proposed future work is subject to change based on funding levels.

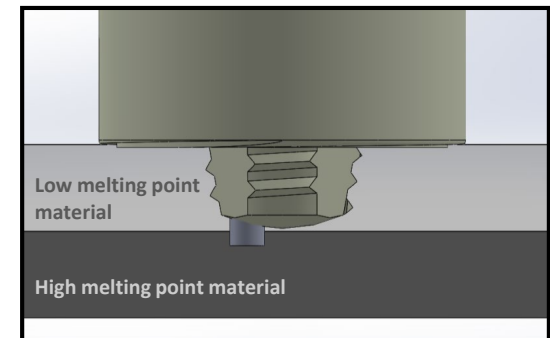
Approach: Friction stir Assisted Scribe Technique (FAST)



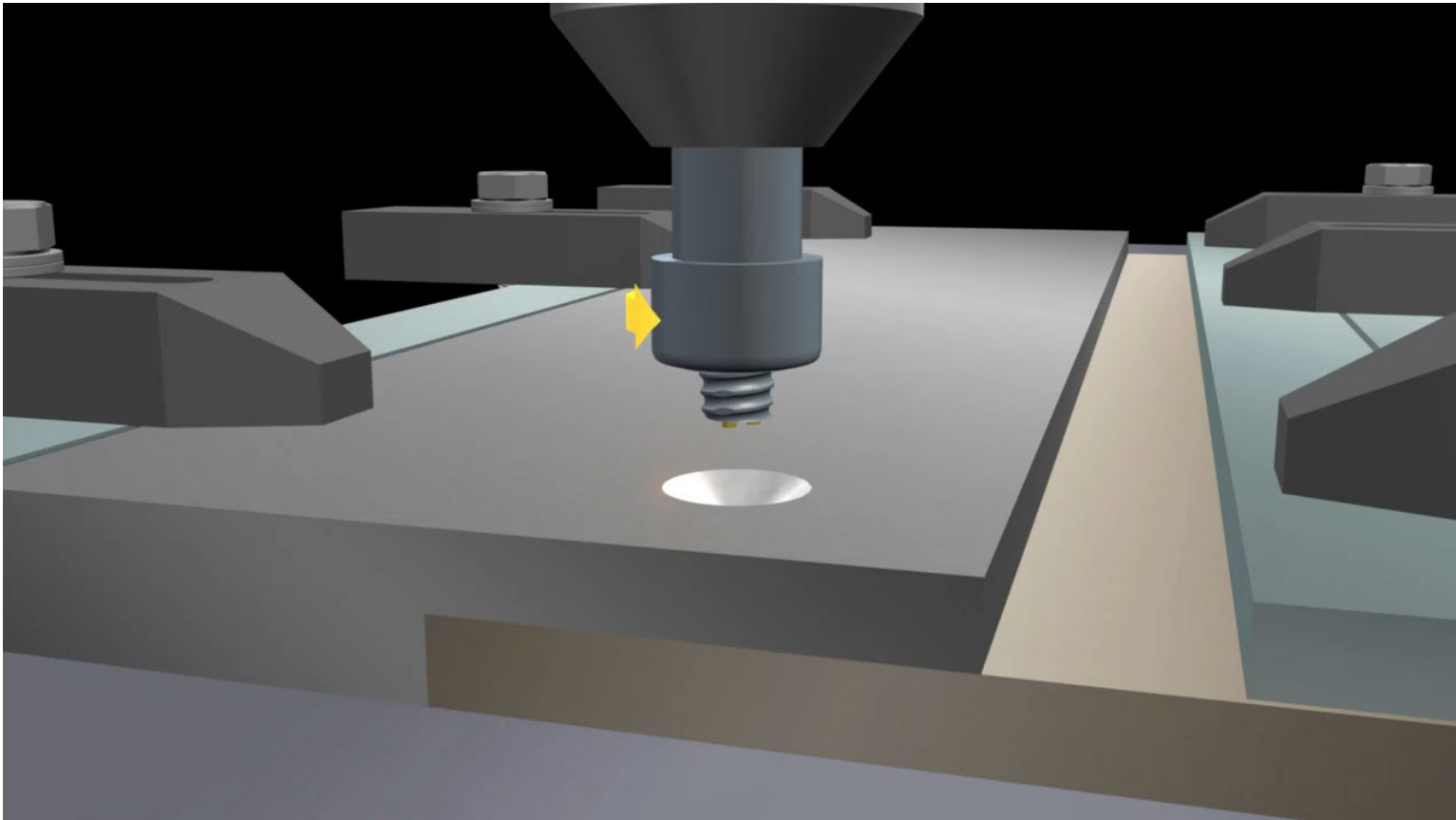
Friction stir scribe tools



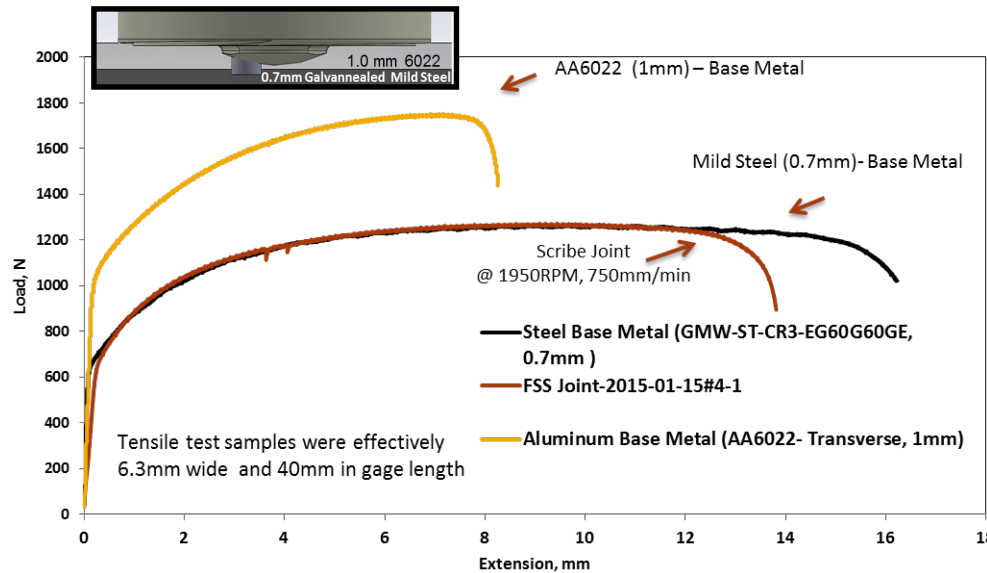
Forms an in-situ mechanical joint because of the formation of mechanically interlocking feature or “hook”



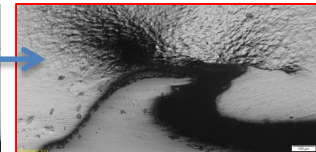
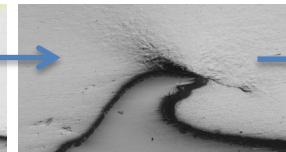
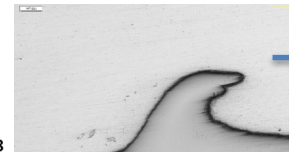
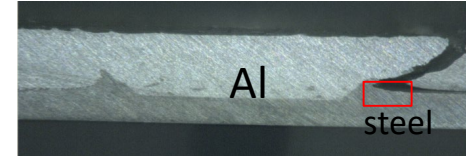
Approach: Scribe process animation



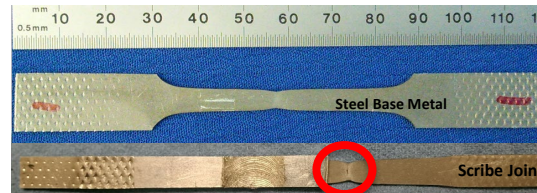
Automotive sheet Aluminum to Body steel [Previous accomplishments]



Fracture in the weld

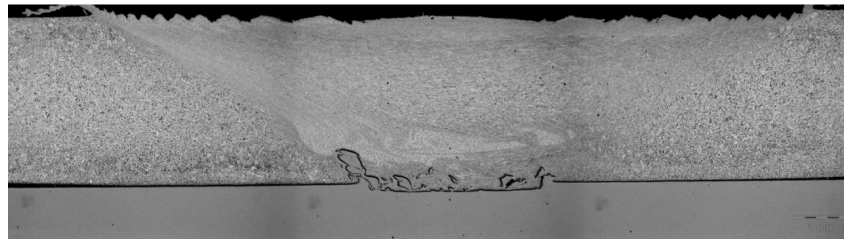
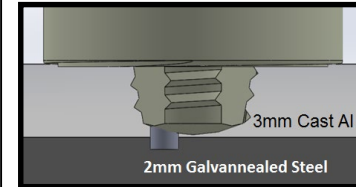
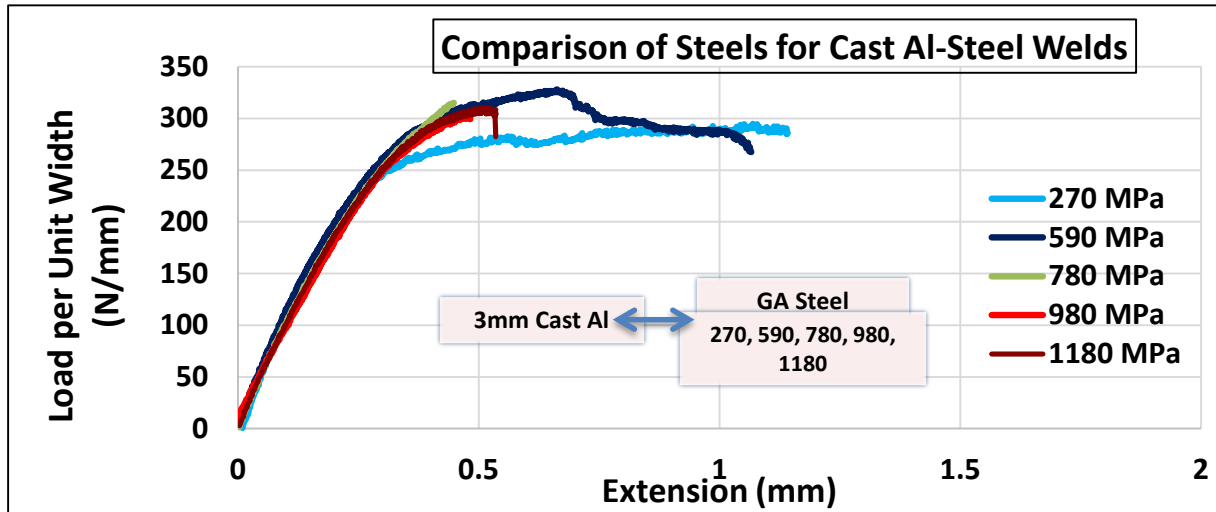


Macro cross-section of joint ~ 7mm away from the location of above tensile data.



Joint strength close to that of base steel and significant elongation (energy absorption) demonstrated for 6022- 270 MPa steel.

Joining cast aluminum to harder steels [Previous accomplishments]



Demonstrated joining of progressively harder coated steels (270, 590, 780 and 980 MPa) to Cast Aluminum

Accomplishments

- ▶ As of submission of this slide (April 2019) work has not started in this project.

Response to reviewer comments

- ▶ Project being reviewed for the first time.



Collaboration and coordination

- ▶ TWB company (Tier 1 automotive supplier) is our collaborating partner.
- ▶ TWB will
 - Provide relevant material sets for the life of the project
 - Provide material combination and configuration with highest potential for being commercialized based on its market research.
 - Lead on subcomponent design and defining of evaluation metric and testing in task 2
 - Provide the usage of FSW equipment, and production line expertise and access of stamping facility towards meeting the milestone 2.

Any proposed future work is subject to change based on funding levels.

Project Summary

The overall goal of this project is to overcome technological barriers in implementing FAST method in a high volume production environment.

The work will assess process techniques, tools and control parameters needed to advance the emerging joining method by improving tool durability and process robustness and transition this work into a production environment.

Milestones and deliverables

Establish material combinations and configurations

Establish mechanical performance criteria

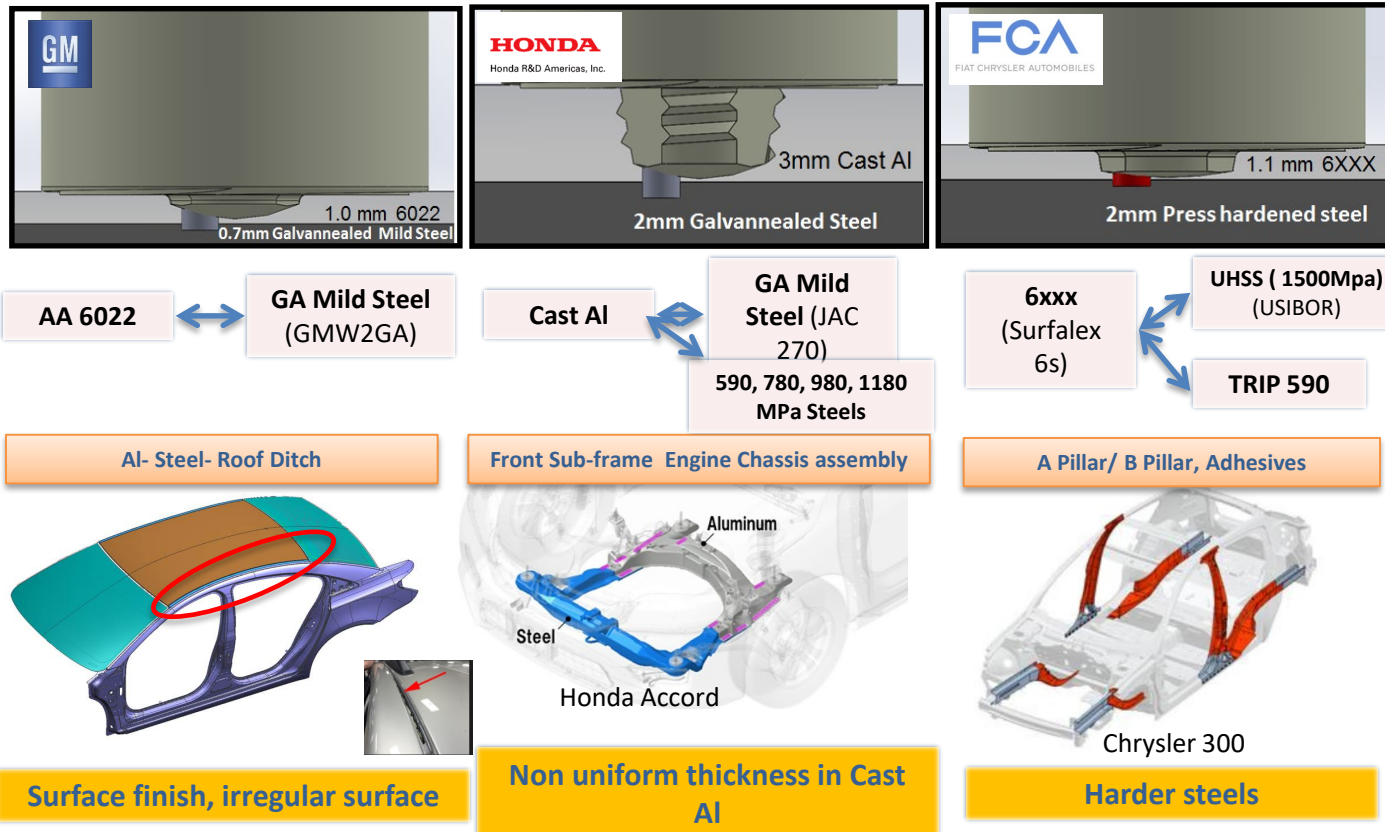
Demonstrate welding speed of 3m/min for Al/steel joint while meeting established mechanical performance criteria.

A set of Friction Stir welding parameters, tooling details and its associated effect on weld properties and fracture modes.

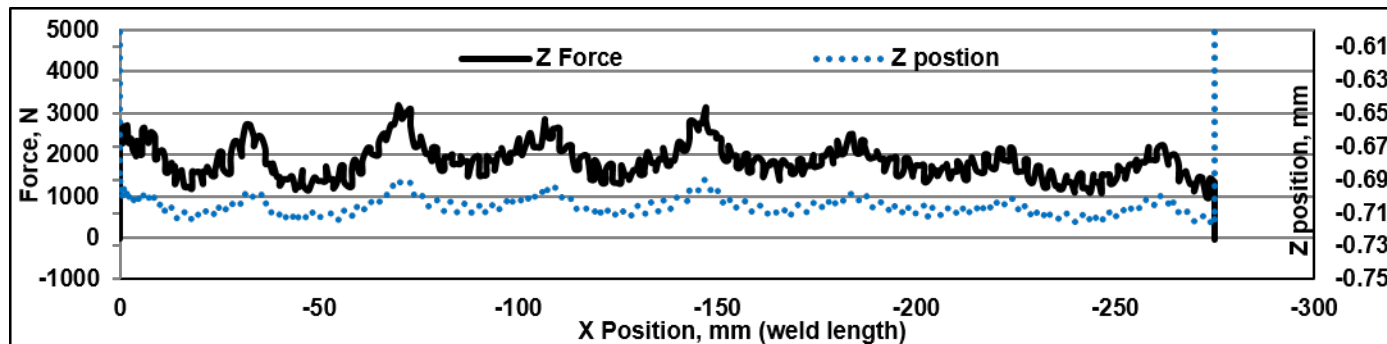
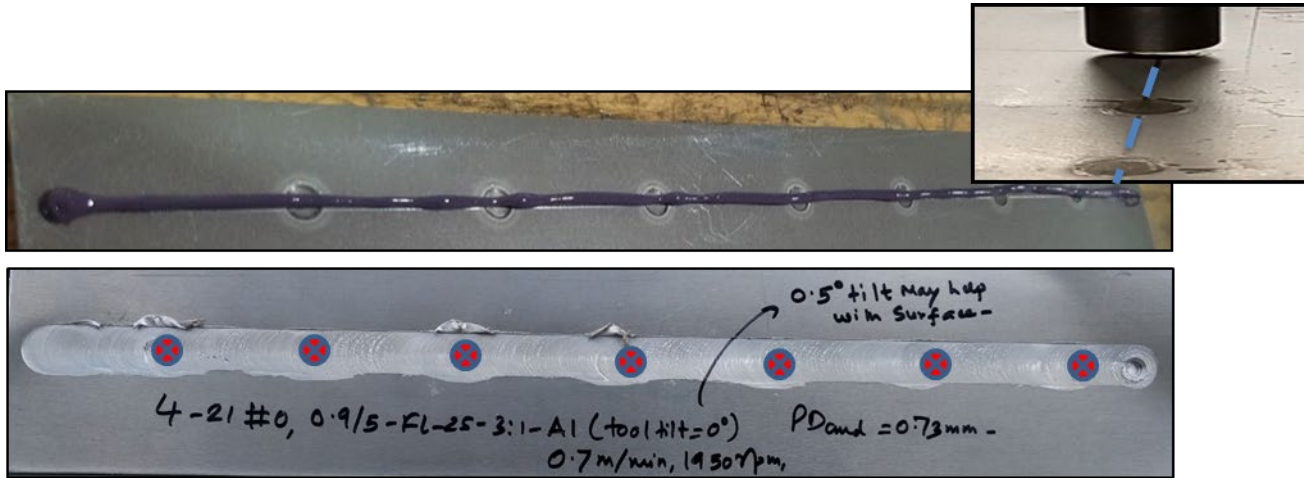
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Backup slides

Material Sets for targeted applications [Previous work]

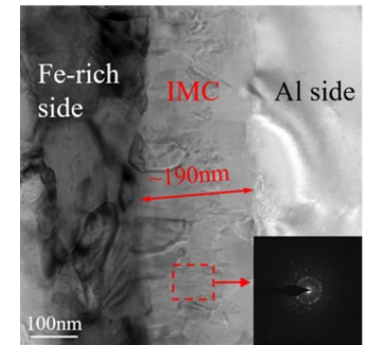
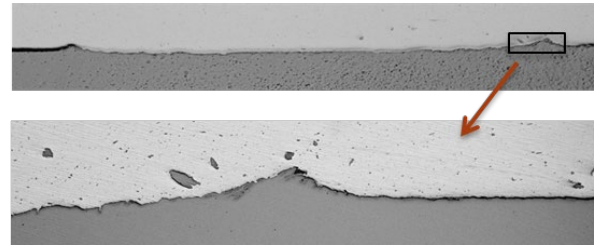
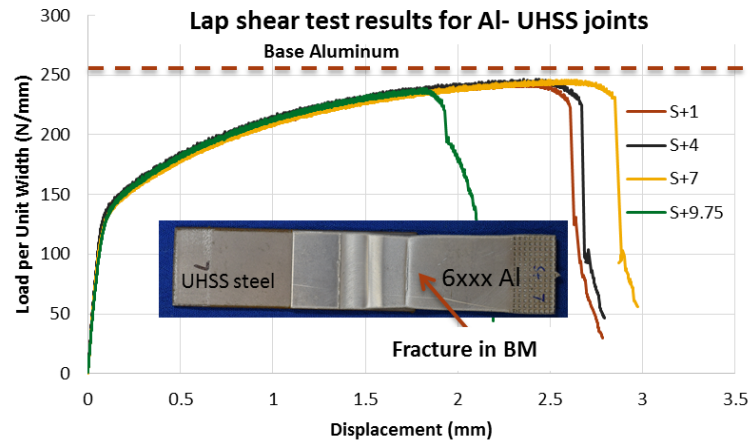


Joining over RSW indents and adhesives



Effective linear joints can be made with indents and adhesive layers.

Al (1.1mm Surfalex)- USIBOR (2.0mm)



TEM micrograph of AL/steel interface

**Fractures away from the weld region demonstrated.
A very thin layer of Fe-Al IMC layer (~200nm) is formed at the interface.**

Ref: Wang, Kaifeng, Piyush Upadhyay, Yuxiang Wang, Jingjing Li, Xin Sun, and Timothy Roosendaal. "Investigation of Interfacial Layer for Friction Stir Scribe Welded Aluminum to Steel Joints." *Journal of Manufacturing Science and Engineering* 140, no. 11 (August 3, 2018): 111005-111005-9. <https://doi.org/10.1115/1.4040873>.

USIBOR (UHSS) cutting challenge



With USIBOR built up edge around the scribe changes the cutting edge significantly thus affecting repeatability.

- ▶ **Challenge:** For UHSS case a tool can only produce 2-3 welds (11" long possible) without tool change.
- ▶ **Potential Solution:** Uni-body tool with both scribe and tool made out of hard material.



High Volume Al TWBs produced by TWB company.



Ford Expedition / Navigator Door Reinforcement

- Series production part FSW 2017
- 3.8 mm to 3.0 mm AA5754